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THESIS

DEVELOPMENT OF IS2100
AN INFORMATION SYSTEMS LABORATORY

by

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March 1985

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T223021

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Development of IS2100 An Information Systems Laboratory		5. TYPE OF REPORT & PERIOD COVERED Masters Degree March 1985
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles S.D. Witten		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, CA 93943		12. REPORT DATE March 1985
		13. NUMBER OF PAGES 40
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution is unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) computer literacy, information systems, laboratory, course development		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) On the premise that fundamental concepts and uses of microcomput- ers can be taught in a hands-on environment, the Administrative Science Department Instructional Laboratory was established. IS 2100, an information Systems Laboratory uses these facilities to reinforce material taught in the first two quarters of the Computer System Management Curriculum. Its purpose and objective is to develop computer literacy and introduce the student to (continued)		

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Development of IS 2100
an Information Systems Laboratory

by

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Lieutenant, United States Navy
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Submitted in partial fulfillment of the
requirements of the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
March 1985

ABSTRACT

On the premise that fundamental concepts and uses of microcomputers can be better taught in a hands-on environment, the Administrative Science Department Instructional Laboratory was established. IS 2100, an Information Systems Laboratory uses these facilities to reinforce material taught in the first two quarters of the Computer System Management Curriculum. Its purpose and objective is to develop computer literacy and introduce the student to microcomputers and the facilities of the developing laboratory. This thesis is the report of the development of IS 2100 as first taught during Winter 1985.

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I. INTRODUCTION

A. COMPUTER LITERACY FOR COMPUTER SYSTEMS MANAGEMENT STUDENTS

In 1980 it was decided that the Administrative Science Department at the Naval Postgraduate School should support a microcomputer laboratory for use by students and faculty for research and general use. It was also envisioned that the facility could be used to support an Information Systems Laboratory whose objective would be

"to develop computer literacy early in the Computer Systems student's program and to reinforce lecture material in IS 2000. Students will perform elementary laboratory assignments involving use of microcomputer systems for digital logic; hardware architecture; machine, assembly, and high order language programming; and application packages such as database management and word processing." [Ref. 1]

Computer literacy has become one of the buzz words in society today. As the computer injects itself more into our lives, our jobs, and society as a whole, the need for everyone to obtain some form of computer literacy has become an accepted norm. Failure to learn about computers and their use will leave the uninitiated in a position of being functionally illiterate, without the skills needed to exist in an "information society."

But what is computer literacy? Just as everyone has his own opinion, everyone seems to have his own definition of

computer literacy, even experts in the field do not always agree. Some of the more general definitions that no one can dispute are the ability to function capably in a computer oriented society and whatever a person needs to know and do with computers in order to operate and function competently in an information based society. As one may expect, these definitions include the entire spectrum of skills and knowledge needed by different individuals in different jobs.

The justification for the whole computer literacy movement is that high-tech jobs require high-tech skills, but the majority of jobs that are affected by computers require a level of expertise that could be acquired in a week or two of on the job training [Ref 2]. Most computer literacy courses are hardly adequate training for a career as a computer programmer or analyst. The instigators of the push towards computer literacy seem to be hardware manufacturers and software designers who have found an excellent rallying point to sell their products and ensure their future. But how many home computer systems are sitting in the closet after only a couple months of use?

Computer Systems Management students are not in the category discussed above. To function in their future jobs, computer literacy means a little more than entering data into a point of sale terminal or playing games on an Atari. Computer literacy involves an awareness and understanding of the operational and analytical aspects of computers,

including their applications and limitations. They should be able to define, demonstrate and/or discuss how computers are used, how they do their work, how to use them, and how they affect society [Ref. 3].

The Computer Systems Management curriculum enhances the development of this literacy. Surveys of business and industry have shown that business courses such as accounting, information systems, business communications, financial management, principles of management, elementary statistics, principles of economics and organization theory are important in being able to function in business today [Ref. 4]. These areas are well represented in the Computer Systems Management curriculum. The same survey also shows that heavy emphasis is desired in the technical areas of systems analysis, file processing, data structures, database processing, management information systems, distributed processing, statistical methods and assembly language programming. Although these areas are dealt with in less detail by the manager as compared to the technician, a basic understanding is essential. The Computer Systems Management curriculum covers the majority of these adequately, but unless the student is in the Tactical emphasis area or overloads his/her own emphasis area with courses such as Digital Logic (EE 2810) or Computer Architecture (CS 3200), a basic understanding of computers may be lacking. These courses, not required of most Computer Systems Management

students, help provide some basic understanding of computer logic, architecture and organization that may not be assimilated when studying the theory about larger machines and systems. By using microcomputers and their components, these courses help the student comprehend and use terms about microcomputer hardware and software that will stand them in good stead when referring to larger systems. They develop a better understanding of the operational scheme of a computer, learning their uses and limitations. Hands on operation of the hardware and software provides experience that aids in future selection of hardware systems and applications.

Using microcomputers and personal computers gives students experience and develops computer literacy, an area that is lacking in many of today's computer system or data processing manager's backgrounds. With the proliferation of personal computers that have been brought into industry and business comes the problems of control and consolidation. The computer system manager's traditional job description is challenged as he/she tries to manage the personal computer revolution. Establishment of support groups, communication, and the sharing of applications between personal computer users becomes part of the job of a computer systems manager. The manager must be able to solicit and understand evaluations from experienced users, provide applications-oriented educational materials, delegate maintenance

responsibilities, and develop procedures for controlled access to central mainframe systems [Ref. 5].

Computer literacy has become the issue it is today because of the explosion of microcomputers. The word microcomputer in itself means many things to many people. It can mean an MOS LSI processor, a single chip computer, an 8-bit computer, a dedicated computer or a small computer. In this context it will mean an inexpensive or personal computer. The driving force behind the explosion of microcomputer technology has been an economic one. Today's micros are more powerful and easier to use resulting in an explosion that has developed a multi-billion dollar industry.

With the idea that microcomputers are important to the computer systems manager a literacy must be built up that includes them too. Four distinct areas should be considered. First, the ability to understand growing economic, social and psychological impact of microcomputers. The ability to make use of ideas from the world of computer programming and applications to integrate microcomputers into strategies for information retrieval, communication and problem solving. The ability to use a variety of systems in personal, academic and professional contexts. Finally, the ability to control and program microcomputers to achieve a variety of personal, academic and professional goals. [Ref. 6]

B. EXISTING LABORATORY FACILITIES

The present Administrative Science microcomputer facilities are the culmination of an effort by Professor Schneidewind and three students who have done previous thesis research in developing the laboratory as a whole. These students, Kenneth J. Mills, Jesse M. Richards, and Glen F. Tilley, joined the project in the Fall of 1982. This was well after its inception by Professor Schneidewind, but in time to have a significant input into the design before construction started in September of 1982.

The Administrative Science microcomputer laboratory is located on the ground floor of Ingersoll Hall in room 158. The present set up has an exterior room and an interior room, both of which are protected by cipher locks.

The exterior room is the larger of the two and is occupied by a Coast Guard multi-user microcomputer system. Although this system was not originally planned for the laboratory, it was included when the system became available through an offer by the Coast Guard. The system became operational in November 1982 and requires most of the workstation space in the exterior room. The system is used primarily by Coast Guard students for thesis research and to remain current in the use of a system identical to those found at most Coast Guard facilities.

The Coast Guard system was developed by C3 Inc. under licensing agreement with Convergent Technologies. There are

a total of five workstations, a monitor station, an integrated work station, and three application work stations. Equipment consists of high resolution terminals, keyboards, and electronics packages based on the 8086 microprocessor. Input/output interfaces consist of RS-232 connections for monitor and other integrated workstations and RS-422 connections for all workstations. Mass storage configuration consists of 40 megabytes of hard disk storage and one 8 inch floppy disk drive. Other peripherals provided include a high speed dot matrix printer, a letter quality (daisy wheel) printer, and a 300/1200 baud modem for communications. The operating system provided is the Convergent Technologies Operating System (CTOS). Software provided includes BASIC, FORTRAN, COBOL, Pascal, Assembly Language, and general word processing.

New user orientations are held quarterly by the current systems manager, normally a U.S. Coast Guard student. The system is available to all Naval Postgraduate School students for thesis research and general use. Current loading is mostly Coast Guard as the system is pretty formidable for the uninitiated. Other students usually have not had contact with a system similar to this before and will probably not have use for it in the future. The appeal of the system is therefore limited because it is not used significantly by the Department of Defense.

The laboratory also contains equipment representing the building blocks of microprocessors, digital logic. The Heathkit Digital Logic Training Device and the DD-1 Digi-Designer by E & L Instruments Inc. can be used to teach students digital logic fundamentals and give them "hands on" experience that would not otherwise be possible without their taking EE-2810. These units include necessary power supplies, selectable frequency clocks, pulsers, logic switches for applying voltage or ground, and lamps/light emitting diodes for outputs. Equipment accessories include 22 gage wire for connectors, integrated circuit implementations of a variety of logic gates and flip-flops. These accessories can be "breadboarded" onto the Heathkit Digital Logic Training Device or the DD-1 Digi-Designer to reinforce lecture material that is presented in CS-3010 and reiterated in IS-2100. These digital logic designers and accessories are normally stored for safe keeping and are brought out as needed for the laboratory sequence.

The next category of equipment consists of elementary single board microcomputers for development of a basic understanding of microcomputer architecture and machine language programming. The Intel Prompt 80 and the Intel SDK-85 microprocessor development system are excellent machines for this purpose because of their simplicity and relative ease of use.

The Intel Prompt 80, is a complete, low cost, fully assembled microcomputer that has an 8080A microprocessor, 1 kilobyte of random access memory for monitor and user programs and up to 4 kilobytes of ROM for monitor and built in functions. These built in functions include reading and writing to programmable read only memories (PROM), paper tape routines, hexadecimal calculator, and various memory move and search routines. The systems monitor drives these functions and a group of simple commands that enable the user to examine/modify a register, display/modify memory, move to the next or previous register and memory location, execute programs, single step programs for debugging, and scroll the register display group. Commands are entered in a relatively natural sequence that makes the machine easy to use. Displays consist of seven segment LED's for the command function group and the register display group, and single LED's for each bit of the input and output registers. [Ref. 7]

The Intel SDK-85 microprocessor development kit is also a low cost microcomputer that has been implemented as a kit. The kits have been assembled by Prof. Schneidewind but as they are not enclosed in a protective case, they provide the student with what may be one of their few glimpses of a circuit board. This implementation has the Intel 8085A central processor unit which is an enhanced version of the 8080A found in the Prompt 80. It is software compatible

with the 8080A while offering higher integration, higher performance, and improved system timing. Memory in this system consists of 2 kilobytes of ROM expandable to 4 kilobytes used by the monitor system and 256 bytes of RAM expandable to 512 bytes used by the monitor and the user. The SDK-85 has the same set of commands as the Prompt 80 with the exception of the scroll register display as it does not have one and there is no facility for backing up to the previous entry. There is no facility for PROM programming or any of the other functions found on the Prompt 80. [Ref. 8]

The final group of equipment that the Administrative Science laboratory has is a variety of personal computers which include a Heath H-89, a Zenith Z-100, and an IBM PC. The Heath represents an older 8-bit machine while the Zenith contains a more modern set up with the same 8-bit central processor and, in addition, a 16-bit processor. The IBM represents the present industry standard for 16-bit personal computers.

The Heath H-89 was assembled from a kit. The computer is based on the Zilog Z80 microprocessor, a replacement for the Intel 8080. The Z80 includes a clock, system controller, and some additional facilities on a single chip. It's instruction set is upwards compatible with the 8080, this makes using it for machine and assembly language programming a little easier for the student who learned the

8080 instructions for the Prompt 80 and SDK-85. The Z80 has an architecture that closely follows the 8080 and, additionally, has an extra bank of registers that duplicate the general purpose registers resulting in the speeding up of many applications. The system is provided with 64 kilobytes of RAM, an amount that is considered standard for present 8-bit machines. It is set up to run with, and is supplied with, the Digital Research CP/M (Control Program/Monitor) operating system, a defacto standard for similar microprocessors. The H-89 has a single internal hard sectored 5.25 inch disk drive and two external soft sectored quad density (96 tpi) 5.25 inch disk drives. An internal CRT provides a standard 80 character by 25 line display and the system is connected to a Heath H-25 132 column dot matrix printer.

The Zenith Z-100 is a new addition to the laboratory. It has an Intel 8085, the enhanced version of the 8080, and runs the CP/M operating system; so most any work designed for the H-89 can also be run on the Z-100. As mentioned previously the Z-100 also has a 16-bit CPU as a co-processor, it is the Intel 8088. The 8088 inherited many of the architectural features of the 8080 so, again, students should not have a difficult time transitioning to 8088 assembly language programming. Direct compatibility with the 8080, as with the 8085 and the Z80, was not desired, and, therefore, some features of the 8080 were not

implemented. The 8088 has all the registers of the 8080 plus some additional ones; the general register group may be addressed by byte, meaning that they may be used as 16-bit or 8-bit registers. The laboratory Z-100 has 448 kilobytes of memory and can be run under CP/M using the 8085 or under Zenith Disk Operating System (ZDOS) using the 8088. The Z-100, as implemented here, is a low profile version with CPUs and two double sided, double density, 5.25 inch disk drives, in one cabinet and a standard 80X25 CRT in a separate cabinet. There is also a 132 column Zenith printer identical to the H-89's Heath H-25 printer available for use with this system.

Finally, the last major piece of equipment in the laboratory is the IBM Personal Computer (PC). This system is similar to the Z-100 8088 system described above in that it uses an Intel 8088 CPU run with PC-DOS, IBM's version of Microsoft's MS-DOS. The CPU is housed with two double sided, double density, 5.25 inch disk drives and has a separate color CRT. An IBM 80 column dot matrix printer is available for use with this system.

II. BACKGROUND

A. NECESSARY SKILLS

The Computer Systems Management student completes a curriculum that is interdisciplinary in nature. To begin with , the majority of students attend a refresher aimed at bringing them back up to academic speed after what may have been many years since last being a student. In the past, a review of calculus, a course in logic, and instruction in the use of programmable calculators has been taken. During the student's first official quarter courses in Structured Programming (CS 2810), Introduction to Computer Management (IS 2000), Organizational Systems (MN 3105), and Accounting (MN 2155) are taken. The second quarter continues with Computing Devices and Systems (CS 3010), ADP Acquisition (MN 3307), Economics (IS 3170), and Statistics (OS 3101). The third quarter rounds out the basic courses, giving the student a solid footing for advanced courses in the curriculum to include an emphasis area and thesis research. The course load in the third quarter consists of Operating Systems (CS 3030), Economics of Information Systems (IS 3171), Operations Research (OS 3004), and an emphasis area course.

As the student enters the fourth quarter, much of the work he /she has done previously is put to use. Courses in

Software Design (CS 3020), Computer Communications and Networks (IS 3502), and selected emphasis area and thesis work are undertaken. The fifth quarter again provides time for an emphasis area course and thesis research in addition to Financial Management in the Armed Forces (MN 4151) and Applications of Database Systems (IS 4183). The Computer Systems Management student's sixth, and last, quarter is a capstone quarter. Case studies and analysis are the meat of Information Systems Management (IS 4182) and Systems Analysis and Design (IS 4200). Again, time is allotted for an emphasis area course and thesis research.

With the background discussed above the student should be able to do well in most future assignments. An area that is not covered well in the normal sequence, and may prove to be a weak area later on, is the use and implementation of microcomputers. In the past, most student's only contact with microcomputers has been in their database course (IS 4183) where they used database software on microcomputers to design a small database project. Many students had had no previous microcomputer experience and were therefore at a disadvantage.

Another course that discusses uses of microcomputers and their integration into the corporate environment is the course on information systems management (IS 4182). This course is a series of case studies, many of which discuss the use of microcomputers and their impact on the data

processing manager. It is evident from these studies that corporate managers expect the data processing manager to manage the growth of personal computers. From studies in IS 4182 it is apparent that the uncontrolled growth of personal computers in an organization is unhealthy; they threaten the continuity and security of an organization as well as the effectiveness of the data processing manager.

Mills, Richards, and Tilley [Ref. 9] discussed at length the need for communication between the non-EDP business manager or executive and the computer scientist and programming staffs. They stated that the role of the information specialist should be to bridge the gap between these two diverse areas. They also discussed the Association for Computing Machinery (ACM) guidelines that delineate technical expertise of the Information Systems graduate as having the ability to develop an information systems structure for organizations and to design and implement applications.

The curriculum, as described, supports these goals to a great extent. But it falls short in the area of how off-the-shelf personal computers are being used in a variety of ways and at a number of levels in business and industry today. The microcomputer is a common enough tool that it should be covered in some fashion that will aide the Computer Systems Management student in adapting to new roles as a bridge between managers and technical personnel.

It should not be the goal of the Administrative Sciences Department to provide in depth technical education, but only to introduce microcomputers and reinforce concepts and ideas taught in other courses in the curriculum. A broad approach to microcomputer devices and systems that will provide the minimal necessary skills to incorporate microcomputers into the curriculum is all that is needed.

B. EXISTING COURSEWARE

Through the efforts of Professor Schneidewind and thesis students Mills, Richards, and Tilley, a series of tutorials has been developed to aid the student in learning about particular pieces of equipment in the Administrative Sciences laboratory. In most cases these tutorials are adaptations of the user's manuals and reflect the author's experience with the equipment. They give the reader a basic introduction to some of the theory and mechanics of the equipment. The tutorials are generally more "user friendly" than the technical material from which they were derived and an attempt was made to provide some uniformity in text style for instructional material that was to cover a wide range of equipment. No attempt was made to replace the user's manuals and guides; the effort was solely to give the novice an easier starting point, rather than having him delve into equipment documentation.

One of the most complete tutorials developed was one for the DD-1 Digi-Designer. This tutorial, entitled DD-1 Digi-Designer: Logic Circuit Design Methodologies, reviews binary mathematics, logic design and boolean algebra, Karnaugh maps, and flip-flops. A series of five laboratory experiments introduce the student to the Digi-Designer and reinforce the material that has been reviewed. A similar tutorial was developed for the Heathkit Digital Logic Training Device. A thorough description of the equipment is followed by references to the Heathkit manual for a series of five experiments demonstrating the features of the equipment in a fashion similar to the Digi-Designer.

Another extensive tutorial was developed for the Prompt 80. A description of the equipment and the available functions are covered, along with a walk-through of an example program. An introduction to assembly language programming, from flow charts and algorithms through machine coding, is described. Advanced concepts of debugging and use of programmable read only memories (PROMs) are introduced briefly. The SDK-85 tutorial was developed along the same lines as the Prompt 80 text but is not as comprehensive, giving only a description of the equipment and its functions.

A tutorial was also developed for the Heath H-89 microcomputer that provides a brief description of the computer and its peripherals. Instructions on powering up

the system, powering down, and booting the operating system are included. A cursory look at the CP/M operating system is also provided, disk drives, files, control characters, built in commands, and utilities are introduced.

III. WINTER 1985 IMPLEMENTATION OF IS 2100

A. COURSE OBJECTIVES

IS 2100 was implemented for the first time during the Winter term of 1985. There were three specific objectives. The first was to provide computer literacy in various microcomputers and related devices. In association with that, problem logic implementation at various levels of computer architecture and relationships between these levels was to be shown. The final objective was to introduce the student to the capabilities of the Administrative Sciences Department Instructional Laboratory as a facility for obtaining hands-on experience with various microcomputer hardware and software and the availability of its use for independent work and support of thesis research.

The course was taught by Prof. Schneidewind with the assistance of Instructor Barry Frew and the author. The course was structured into five assignments, to be completed at two week intervals. The class met the first week for lecture and explanation of the lab assignment while the second week was left open for questions and time to work on the lab. Each assignment was due by class time of the next lecture session. Grading criteria was divided as follows: 30 percent for lab assignments (6 percent per assignment), 10 percent for lab performance and demonstration, 20

percent for the midterm examination, and 40 percent for the final examination.

An extensive list of reference material was listed for the course. The Digi-Designer tutorial, Prompt 80 tutorial, and H-89 tutorial discussed in chapter 2 were loaned to each student. In addition, Leventhal's 8080A/8085 Assembly Language Programming and a copy of Intel's 8080/8085 Instruction Set Reference Tables were provided. Purchased texts for the course included IBM's Personal Computer and The Osborne/McGraw Hill CP/M User Guide. Self paced tutorials for the IBM PC entitled Exploring the IBM PC, DOS Made Easy, and PC Plus were provided in the laboratory on diskette for student use.

Because of a lack of facilities and equipment, and to enable more knowledgeable students to help others, the lab assignments were designed to be a team effort. Only one report was required per team. Each team member was responsible for demonstration of at least one lab, although each group received identical grades for written work. Variation in performance grades was possible due to individual demonstrations and knowledge of the assignment as determined by the instructors.

The five assignments were designed to introduce the student to different levels of computer architecture while giving them hands-on experience at each of those levels. The areas covered included digital logic, machine language

programming on elementary microcomputers, assembly language programming on advanced 8-bit and 16-bit microcomputers, and application packages on 16-bit microcomputers. The broad goal of the sequence of the assignments being that of making the student literate and comfortable using today's microcomputers.

B. ASSIGNMENTS

The first assignment was based on digital logic. Readings for this assignment consisted of the DD-1 Digi-Designer: Logic Circuit Design Methodologies, a tutorial described in chapter 2. During the lecture Boolean variables, Boolean functions, and truth tables were discussed. Examples of truth tables specifying all combinations of a Boolean function and the Sum of the Products representation for finding the function were introduced. Karnaugh maps were then used to simplify the functions without resorting to Boolean algebra. Once these basics were understood, integrated circuits and their use on the DD-1 Digi-Designer for solving the lab assignment of Fault Tolerant logic were described.

Readings for assignment two were from the Prompt 80 tutorial and Leventhal's 8080A/8085 Assembly Language Programming. Topics covered were familiarization with the Prompt 80 and the 8080/8085 instruction set. The specific objective of the lab was hardware familiarization. During

the lecture portion of the lab, specific instructions that could be used for the lab assignment were described and discussed. The concept of user interrupts was covered extensively and the procedure for programming and dumping programmable read only memories was detailed. Fault Tolerance was again used as the example and its implementation using software (a machine language program) was explained.

Assignment three introduced the IBM PC and reading assignments for this lab included topics on PC DOS and assemblers from IBM's Personal Computer. Objectives for the lab were to demonstrate the use of a computer for software development for a target computer and use of the PC for directly solving the Fault Tolerance problem previously demonstrated in hardware and in machine language. Register equivalents between the 8080 and 8086/8088 architectures were discussed before identifying instructions from the 8086 instruction set that could be used for this lab. Several copies of The 8086 Book were provided in the lab as reference material. Assembler directives and procedures needed for implementation of this lab were explained in detail so that the student would not have to learn the intricacies of the assembler. Procedures for making the students program correctly interface with DOS were also detailed.

Laboratory assignment four also used the IBM PC, but in this case the student was shown how to use an application package on the microcomputer with the objective of introducing the student to modern applications for microcomputers. A representative database package was used with an automated system for keeping a personal address/phone directory. The operations of the database were presented in enough detail so that the student could easily use the system. Additionally the student was provided with a command summary so that he/she could manipulate the database without using the directory system. The lab assignment included use of the directory and use of the database directly.

The fifth and final lab was a familiarization with a representative CP/M system. Readings for this assignment included topics on microcomputer and operating system development and use from The Osborne/McGraw Hill CP/M User Guide. Questions about diskettes were covered as well as questions on filename extensions. Basic operating system structure and memory organization were described. CP/M built-in and transient commands were covered in general and utilities such as the Dynamic Debugging tool (DDT) needed to complete the lab were explained in detail. The lab assignment again used the familiar Fault Tolerance problem and reimplemented it using DDT.

C. LESSONS LEARNED

As with the implementation of anything new, there were problems that developed. In general, there existed an attitudinal problem among many of the students. Some students perceived that the course was added with no corresponding decrease in other areas. Actually a course in the use of the TI-59 calculator had been eliminated from the program. However, some students felt that the course was an unnecessary overload and a burden on their time. Additionally, after the first two lab projects were completed, many students felt that the one credit hour that they received for the two hour lab did not warrant the effort that they were putting in. Although the actual lab experiments were not very complicated, familiarization with the equipment or software required a significant amount of time.

Another problem was an aversion to learning machine and assembly language programming. Some students seemed to feel that they were never really going to need to write assembly language programs and thought that having to do this in IS 2100 was a futile effort. While this may be true for large computers, recent trends show that there is a good chance that some graduates may have to write or review assembly language programs for mini or microcomputers [Ref. 10]. The idea of using assembly language as a way for the student to

become aware of what happens at the machine level should be stressed in IS 2100.

To help students get over some of these phobias, the instructors were available in the laboratory for extended periods of time. An instructor was available in the lab four afternoons per week. In addition instructors were on call at most any time during the work day. With the wide variety of equipment and the disparity in experience of the students, it was important to have an instructor available to avoid wasting students' time in overcoming problems which were not designed to be part of the lab assignment. The time spent by the author in the Instructional Lab is documented in Figure 1. This assistance was provided for three hours, two afternoons per week. In addition assistance was given on an as needed basis for some of the more troublesome assignments.

TASK	HOURS EXPENDED
Lectures attended or given	16
Equipment checkout	15
Laboratory preparation	12
Scheduled laboratory availability	54
Additional availability by request	8
TOTAL HOURS	105

Figure 1. Laboratory Hours

One session of each lecture was attended by the author. He also attended the second section's meeting, as necessary. Equipment checkout consisted of ensuring operability of equipment on loan to the laboratory and trouble-shooting of the lab's H-89 microcomputer. Each lab assignment was completed by the author prior to his scheduled time in the laboratory.

IV. CONCLUSIONS AND RECOMMENDATIONS

Microcomputers and their use are important to the Computer Technology student. In the Computer Systems Management curriculum, there were no required courses in computer architecture or microprocessors in three out of four emphasis areas. The Computer Center and Network Operations emphasis area and the Decision Support Systems emphasis area offered no way of directly obtaining skills in this area and the Information and Computer Networks emphasis area offered a course in computer organization only as a possible elective. The Tactical Systems emphasis area was the only option that required a course that taught necessary skills for understanding microcomputers and gaining the associated literacy.

The introduction of IS 2100 was a needed addition to the Computer Systems Management curriculum. It has at least introduced students to concepts involving many levels of computer architecture, giving them a place to start in developing new skills. Its introduction was not without some consternation from the first group of students to take the course. They saw it as an added burden and were not entirely enthralled by having to work with the variety of machines in lower level languages.

As the course progressed most students seemed to increase their understanding of microcomputers and appreciated the course a little more. The problem at this point was the amount of time and effort that the lab assignments were taking relative to the perceived benefit in credit for a course that represented only one of eighteen hours credit for the quarter. When pressures of midterms and finals were at their highest the attitudes of the students towards a lower credit value course seemed to be most negative.

The subject of attitude towards the new course is similar to attitudes towards the thesis when it was first introduced to the curriculum. The first group of students to write a thesis were aware that there had been no previous requirement. Consequently, they were not very receptive to the idea. As IS 2100 is taught to successive sections this feeling should tend to wear off just as it has with the requirement for a thesis. Fewer growing pains for future students and the smoothing out of the course of instruction will lead to a greatly enhanced attitude.

As far as facilities are concerned, the laboratory facilities are inadequate with respect to space and availability of equipment. The lab was well developed, but the addition of the Coast Guard system, described in chapter 1, severely limits the space for other equipment. The space is not adequate for the 50 students that now comprise the

average Computer System Management section. It must also be remembered that the lab is not solely for the use of the IS 2100 student, it is also used by students taking Computer Communications and Networks (CS 3502) and by thesis students.

When possible, the Department should expand the facility, including more space and more equipment. Additional microcomputers such as the IBM PC and the Z-100 would make the lab available to more students, while making the logistics of teaching courses much easier. Better and larger facilities could foster more interest in research and thesis work in this area as well as taking the load off the main campus computer at times during the quarter when this machine is saturated.

Future instructors of IS 2100 may again want to enlist the help of students to assist in the laboratory as part of thesis research or directed study. The need for students to have immediate access to assistance is apparent. Interested students with the proper background can help in many ways to conserve the valuable time of the instructor.

The course is indeed an important area for the Computer Systems Management student. The explosion in use of microcomputers makes understanding them an important part of the manager's broad responsibilities. Literacy in this area of computer management is as important as that of any other

segment of computer management, and is crucial in the rapidly growing microcomputer market.

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